APPLICATION OF PRESTRESSED COMPOSITE TRUSS GIRDER IN INCHEON BRIDGE PROJECT

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Abstract : Unseo 2nd Bridge of Incheon Bridge connecting road 1st section is a PCT girder bridge connecting Incheon International Airport and Songdo International Business District an economic free zone. Girder bridge consists of concrete bottom slab component with a certain stress, composite component of steel or rolled H-beam and upper slab of steel-concrete composite components. This girder bridge is a hybrid structure of a new concept characterized by composite girder bridge where main girder is constructed first and then bottom slab follows and composite truss bridge, having been developed by a pure domestic technology. In particular, as the existing road network connecting with Yeoungjong Sky City currently under development is penetrating through the sub road of Unseo 2nd Bridge, PCT girder bridge with aesthetic sense and a feeling of opening has been applied, matching with surrounding scenery.

Keywords: PCT, Incheon Bridge, hybrid structure, Hybrid Bridge, Composite Truss, Prestressed concrete, Unseo 2nd Bridge, Preflex beam.

1. INTRODUCTION

Expressway is creating a problem of separating regions in case of passing through the urban center while it is playing a role of providing the fastest way of connecting each separated regions. As a means of solution for this problem, communication between the two separated regions is made to be enabled by constructing highway or subway in terms of a civil works.. Western connecting road located at the entrance of Incheon Bridge Project site is a round trip 6 lane expressway passing through Yeoungjong sky city currently under development. In order to eliminate regional feeling of separation of Yeoungjong sky city under development stage by stages until 2020, aiming at strengthening national competitiveness and an international exchange city based on Northeast Asia, smooth communication and minimized feeling of separation have been envisaged by providing 5 number of bridges at the main road section

only. In particular, sub road of Unseo 2nd Bridge has been designed as a main trunk road (wide road, B=40m) based on Yeoungjong region urban development scheme and PCT girder bridge has been selected considering sufficient securing of limit height and aesthetic aspects as well as economic efficiency at the design stage.

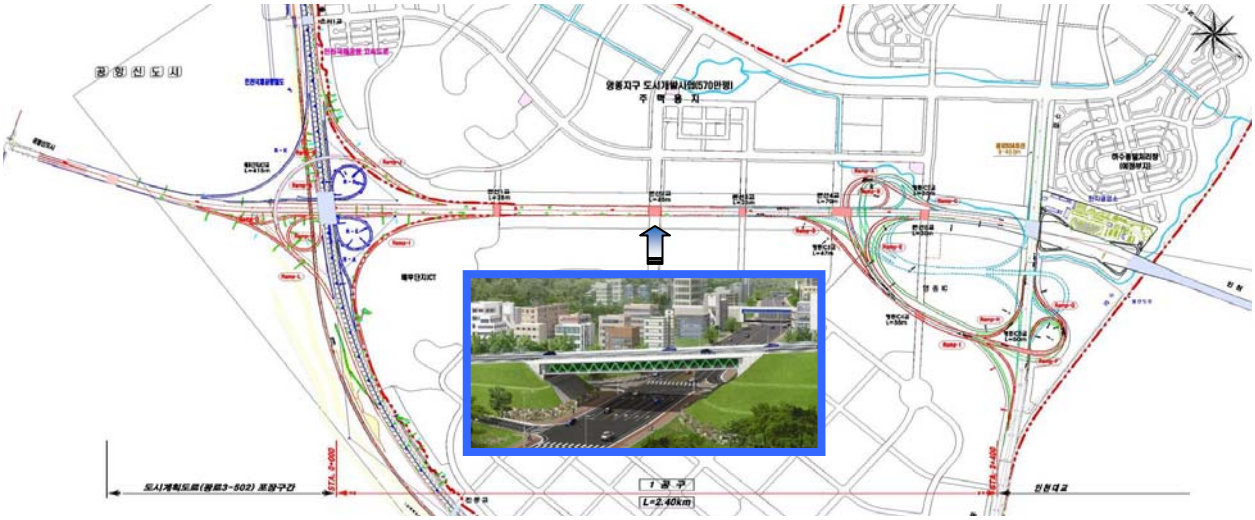

Figure 1: Plan view of Un-seo 2nd Bridge(PCT girder)

2. Characteristics of PCT Girder

2.1 Characteristics of fabrication and temporary construction method

All the temporary working methods (MISS, ILM, FCM, PSM) being applied at the existing PSC box girder bridge could be applied in case of using the method of constructing PCT girder at the site by installing pre-fabricated segments at the shop by using temporary vent and crane under the urban center working environment with a special limit requiring fast track process and the method of constructing pre-fabricated steel structures at the site by combining with concrete bottom slab. The method employed at Unseo 2nd Bridge is to construct pre-fabricated steel structure segments by combining with span unit girder at the site by using crane. Constructional characteristics of PCT girder-bridge is to simplify temporary equipment mobilization significantly due to its light self weight and to shorten the work period considerably.

2.2 Application of Truss Structure

As the self weight increase as a result of span increase, one of the biggest issue in bridge construction, has been solved by application of composite component truss structure, bridges of long span is enabled to be designed and constructed. In addition, as pre-stress equivalent to concrete compression strength could be employed on the bottom slab, stability under extreme load condition could be secured without any significant cost increase and as stress loss and tension stress generation by the binding action of each component could be moderated great, cracking problem during service could be eliminated as well. Furthermore, aesthetic view could be enhanced as the bank angle of composite components could be fabricated with 60 degree near to the golden ratio.

2.3 Application of composite structures to the Upper slab

By application of upper slab of steel structures, tension force and compression force could be resisted and structural continuation of girder at the middle point is allowed without any separate PS steel structure support (application of identical design concept with steel-concrete composite box girder).

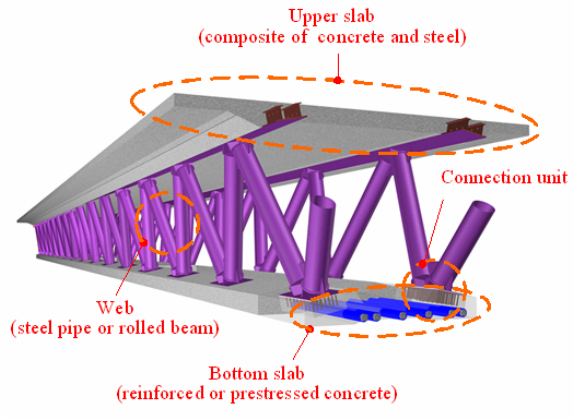

Figure 2: Component of the PCT girder

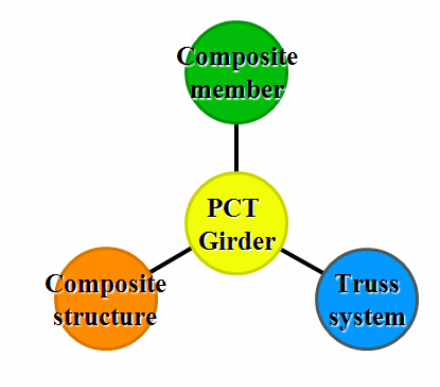

Figure 3: Key words

3. PCT Girder Structure

3.1 Connection structure of bottom slab Panel point

Design has been made so that structural stability could be secured by applying perfobond Rib structure (increasing ductility in case of destruction by penetrating rebar through the hole in traverse direction).

- In case of no penetrating rebar (estimation formula of panel) : $Qu=3.38\ d^2\ (t/d)\times'c-39.0X10^3$
- In case of penetrating rebar (estimation formula of panel) : $Qu=1.45\{(d^2-Ø^2)\times c+Ø^2\times st\}-26.1\times10^3$

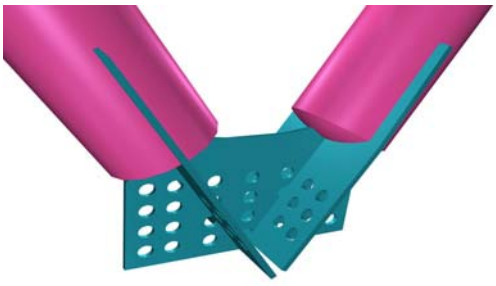

Figure 4: Details of Panel Point

Where,
Qu : shear bearing force per 1 hole(N)
d : hole diameter(mm)
t : thickness of hole plate(mm)
Ø : diameter of penetrating rebar(mm)
fc : concrete compression strength(N/mm2)
fst : tension strength of penetrating rebar(N/mm2)

3.2 Composite Structure of Upper slab component

In order to improve structural behaviour and fatigue features for the employed load of panel point sphere, prefobond rib structure instead of headed stud has been employed for shear connection structure and partial embedment type of embedding a part of upper slab component into concrete inside has been employed. Along with this, shear resistance force has been improved (Dowel action) by aving main rebar to be penetrated through the middle of steel structures.

Figure 5: Details of upper slab components

4. Comparison with other type

Table 1: Comparison of bridge advantage/disadvantage and economic efficiency

classification	PCT Girder Bridge	Steel-concrete composite box girder bridge	PSC box girder Bridge
Overview and cross section			
Main Material quantity	- Steel : 136 ton - Concrete : 413 m3 - PS Steel : 24 ton - Rebar : 62 ton - Form : 1400 m2 - Supports : 2740 m3 - Total weight : 1169 ton	- Steel : 393 ton - Concrete : 254 m3 - PS Steel : 0 ton - Rebar : 48 ton - Form : 528 m2 - Supports : 1999 m3 - Total weight : 1028 ton	- Steel : 0 ton - Concrete : 700 m3 - PS Steel : 40 ton - Rebar : 110 ton - Form: 2013 m2 - Supports : 12500 m3 - Total weight : 1750 ton
Advantage	- Due to low girder height, easy to secure height passing the lower part - Beautiful view of open type - Advantageous for controlling short span bridge (with small curve diameter) negative reaction - Fast construction is allowed - Easy maintenance	- Construction by using medium size crane allowed due to light self weight - Fast construction allowed - Field connection is easy (high tension bolt) - Construction performance is sufficient	- Bearing force and serviceability are excellent owing to one body construction - Low maintenance cost - Low material cost - construction performance is sufficient - No limitation for transport
Disadvantage	- Large crane required for hoisting (Max. 250ton class) - Field welding for steel connection - Separate support required for bottom plate works	- High construction cost - High maintenance cost - Vehicles passing lower part are disturbed by re-painting - re-painting for box inside is difficult - Height limit for transport - - High girder height	- Large scaled supports required - Long work period - Concrete quality control is difficult by site construction - foundation work cost is high due to heavy self weight - Oppressive feeling due to closed structure
Net construction cost for upper part	KRW1,200,000/m2	KRW1,450,000/m2	KRW1,350,000/m2

It could be realized that initial construction cost is cheaper than existing type by 10-20% under the same design condition and total weight is heavier than steel-concrete composite girder by app. 17% but lighter than PSC box girder by app. 30%.

※ Design condition: Span length: 70m, Road bridge: 1st class bridge (DB-24, DL-24)

5. PCT fabrication

▣ Steel Fabrication

Steel pipe slot

Manufacturing

▣ Segment Manufacturing

Upper slab steel component manufacturing

Segment installation

▣ Bottom Slab Construction

Rebar and sheath fabrication

Concrete Casting

▣ Wire Tension

Wire Tension

Grouting injection+

▣ Girder installation

Girder transport

transport/installation

▣ Construction bottom floor

Rebar Placement

Concrete Casting

6. CONCLUSIONS

PCT girder bridge has solved the constructional problem of curved manufacturing through separate fabrication of each component elements, differently from composite girder bridges (PSC beam, Preflex beam, SPG). Problems of self weight increase, pre-stress loss by the binding action between concrete and steel structures has been overcome. In addition, diversified girder manufacturing methods and installation methods could be applied depending on each site condition and by being able to manufacture components of curved configuration freely, aesthetic design has been enabled without being interfered by plane and traverse restriction and therefore this type of bridge is certainly considered to be a bridge type with having an excellent applicability for all the installation areas.

However, various problems including non securing of minimum distance of rebar due to excessive rebar input at the time of manufacturing bottom slab components due to lack of standard drawing, interference between sheath pipe and rebar and loss of public serviceability due to lack of reliability for initial settlement volume and camber volume has been created. In addition, the problem of different design method depending on structural type is considered to be derived from the fact that the domestic design method has not yet been uniformly applied for steel bridge and concrete bridge.

Figure 6: Complete view of Un-seo 2nd Bridge

Therefore in order to apply PCT girder extensively, it is considered that standardization of cross section, standard drawing preparation, standardization of structural calculation, preparation of special specification and standardization for new technology and new working method shall be implemented in advance.

Under the current situation that demand for constructing more infra structures more economically is getting increased, extensive introduction of private technology including new working method, new technology and new materials would be one of the important projects. At the same time, fundamental performance including required quality, function and safety elements as a public facility shall be secured as well. In order to achieve theses objectives, it is considered to be required to establish a technical survey system by any third party including public institutions and private companies in the construction industry more positively.